45 The World of Microbes

READING

Have you had a cold, flu, or other infectious disease recently? Do you know what caused your illness? Microbes cause most infectious diseases. Microbes include the protists, bacteria, and viruses that you classified in Activity 44, "Who's Who?" They also include some fungi, such as yeast and the fungi that cause athlete's foot.

By now you know that *germ* is simply another word for a microbe that causes disease. But you may have also heard the word *microorganism* used. Why, then, do we keep referring to microbes? To find out, you need to know a little more about the differences among the microbes you've studied so far (protists, bacteria, and viruses).

CHALLENGE

How do microbes fit into the classification of organisms?

MATERIALS

For each student

- **1 Student Sheet 45.1, "Anticipation Guide: Diseases and Prevention"**

READING

Complete the "Before" column on Student Sheet 45.1, "Anticipation Guide: Diseases and Prevention."

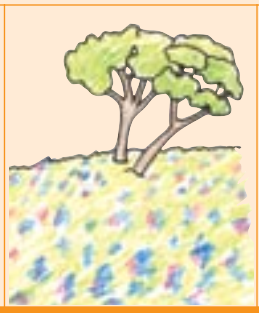
Classifying Organisms

People have invented classification systems to organize and make sense of the many types of living things on earth. As information changes, new classification systems evolve. In Activity 44, "Who's Who?" you grouped the Micro-Life cards based on the physical appearance of the microbes. Until recently, scientists classified organisms based on their appearance into five groups called kingdoms. You are most familiar with the animal kingdom and the plant kingdom. A third kingdom is made up of fungi. The fungi include yeasts (like the one you used in Activity 39, "Cells Alive!"), molds, and mushrooms. Protists and bacteria, like the ones you observed in Activity 43, "Microbes Under View," belong to two additional kingdoms.

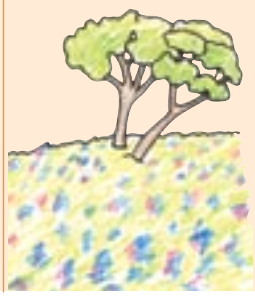
New evidence led later scientists to classify organisms into six groups, dividing the bacteria kingdom into two groups, called bacteria and archaea (are-KAY-uh). Although archaea are made up of a single cell and look like the bacteria you saw under the microscope, they are genetically distinct from bacteria. They are believed to be the oldest form of life, and most of them live in environments that bacteria could not survive in. Archaea can live in extremely salty conditions, like the Great Salt Lake in Utah. They can live in volcanoes and deep sea vents where the conditions are very acidic and extremely hot.

Because archaea are so different from other living organisms, in 1990 many scientists proposed the three-domain system. The three-domain system divides all living things into three groups—archaea, bacteria, and eukaryote (you-CARE-ee-ott) domains. The Eukaryote Domain is made up of all living things that have cells with a nucleus. The Eukaryote Domain includes animals, plants, fungi and protists. Because archaea and bacteria do not have a nucleus, they are considered to be prokaryotes (pro-CARE-ee-otts). Both the five- and six-kingdom classification systems grouped organisms by their physical characteristics, while the three-domain system groups organisms by their genetic similarity. As scientists have continued to collect evidence, the three-domain system has been widely accepted. The three-domain system and its relationship to the older five-kingdom system are shown in the diagram on the next page.

Classification Systems: The Three-Domain Classification System

Eukaryotes				Prokaryotes	
Eukarya (organisms with cells that have a nucleus)				Bacteria	Archaea
					

The Five-Kingdom Classification System

Animals	Plants	Fungi	Protists	Bacteria (Monera)
				

STOPPING TO THINK 1

a. Think about all of the slides you have observed. Have you observed cells from every kingdom? List all of the cells you have observed and the kingdom they are from.

b. Think about all of the slides you have observed. Have you observed cells from every domain? List all of the cells you have observed and the domain they are from.

c. Why do you think the three-domain system was not accepted by scientists right away?

Protists

Protists are single-celled microbes that have a nucleus. While some protists cause illness, many others are harmless. The *Trypanosoma* that you observed in Activity 43 is closely related to another type of *Trypanosoma* that causes sleeping sickness in people. Species of *Paramecium* are often harmless, living in fresh and salt water, where they feed on bacteria, algae, and other protists. Many types of *Amoeba* are harmless, while others cause illnesses of the digestive system.

Bacteria

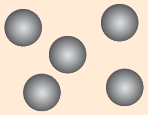
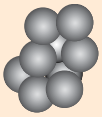
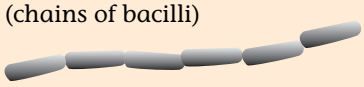
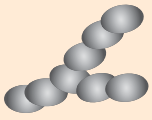
Bacteria are single-celled microbes that do not have a nucleus. Bacteria are also the most common microbes and can be found everywhere—in snow, deserts, lakes, the ocean, and the human body. As you may recall, bacteria are extremely tiny; a thousand bacteria could fit in a cluster on the dot of an "i." There are more bacterial cells in your digestive system and on your skin than the number of cells that make up your entire body!

While some bacteria, such as *Mycobacterium tuberculosis*, cause diseases, other species of bacteria are helpful. In fact, without bacteria, nothing would ever decompose; the world would be full of dead organisms, from the tiniest microbes to large plants and animals! Bacteria also are important in the preparation of foods and beverages. You may have noticed a statement on some yogurt containers: "contains live and active yogurt cultures." That's because yogurt is produced by the fermentation of milk by bacteria! The table on the next page shows the shapes and some information about different kinds of bacteria.

STOPPING TO THINK 2

Would you describe bacteria as being helpful or harmful to people? Explain.

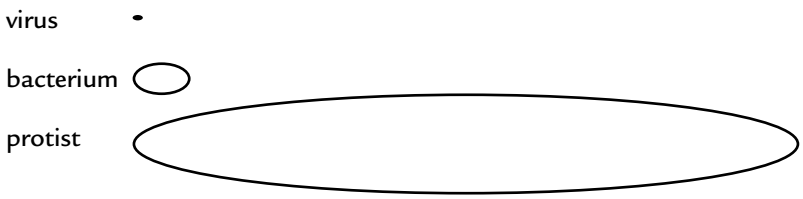
Some Common Types of Bacteria

Shape	Examples	Ecological roles
sphere 	*Diplococci* (pairs of cocci) 	cause pneumonia
	Staphylococci (clusters of cocci) 	are normally present on human skin; some cause boils and infections
	Streptococci (chains of cocci) 	are used to make yogurt and cheese; cause strep throat
rod 	*Bacilli* (rods)	decompose hay; are used to make cheese, yogurt, pickles, and sauerkraut; are normally present in the human digestive tract; cause diarrhea; cause anthrax in cattle and sheep
	Mycobacteria (chains of bacilli) 	cause tuberculosis; are found normally in soil and water.
curved rod 	*Vibrio*	cause cholera; help break down sewage
short spirals 	*Spirilla*	are decomposers in both fresh and salt water
long spirals 	*Spirochete*	cause syphilis; are decomposers
branched chain 	*Actinomyces*	produce several antibiotics; were once classified as fungi

Cocci are spherical bacteria; the singular of cocci *is* coccus.

Viruses: A Group Apart

Viruses are not made of cells. They don't perform most of the functions, such as respiration, that cells do. Viruses cannot grow or reproduce by themselves. Instead, they must invade living cells to multiply. For this reason, many biologists think of viruses as nonliving. However, viruses contain genes and they evolve over time. Some scientists think this means that they are alive. Debate about how to classify viruses is likely to continue for some time. It is because of this debate that we say microbes, and not microorganisms, cause infectious diseases.



COMPARING AVERAGE SIZES OF MICROBES

These are relative, not actual, sizes of microbes. An average bacterium is actually much smaller than the virus shown here.

STOPPING TO THINK 3

a. Why are viruses not considered to be microorganisms?

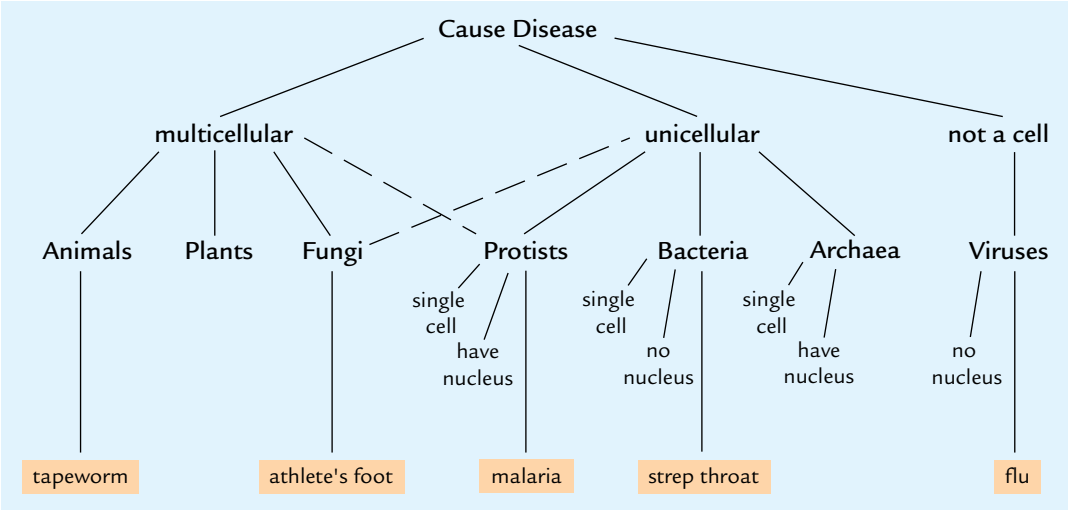
b. Look at the figure above, "Comparing Average Sizes of Microbes." How do the sizes of protists, bacteria, and viruses compare?

c. Which do you think cannot be seen with a classroom microscope?

How do we know viruses exist? The existence of viruses was first suggested in 1898, nearly 45 years before they were first seen. In 1895, Dutch scientist Martinus Beijerinck (BY-er-ink) began experimenting with the tobacco plant. He was studying a plant disease that he believed to be infectious. By this time, scientists were familiar with protists and bacteria, so Beijerinck began searching for a bacterium that might be causing this disease. But he could not find one. Yet his experiments demonstrated that the disease could be passed from plant to plant, so he concluded that the disease was caused by a microbe. Since it wasn't a protist or a bacterium, he called it a virus, which means "poison" in Latin.

Viruses are so small that you need an electron microscope to see one. The electron microscope was not invented until the 1930s. As a result, viruses were first seen in 1939. Today, we know that viruses cause many diseases, including the flu, colds, chickenpox, and AIDS.

The chart below shows the five-kingdom classification plus viruses. Note the examples of diseases caused by members of each group. What do you think the dotted lines mean?



CLASSIFYING DISEASE-CAUSING ORGANISMS AND VIRUSES

ANALYSIS

1. Fill in the "After" column for Statements 1–4 only on Sheet 45.1, "Anticipation Guide: Diseases and Prevention." Did your thinking change?

2. Copy the lists of words shown below:

List 1	List 2	List 3
archaea	animal cell	protists
cellular	cell wall	bacteria
viruses	plant cell	viruses
bacteria	chloroplasts	plants
fungi	mitochondria	can cause disease
protists	nucleus	animals

   a. In each list, look for a relationship among the words. Cross out the word or phrase that does not belong.

   b. In each list, circle the word or phrase that includes the others.

   c. Explain how the word or phrase you circled is related to the other words on the list.

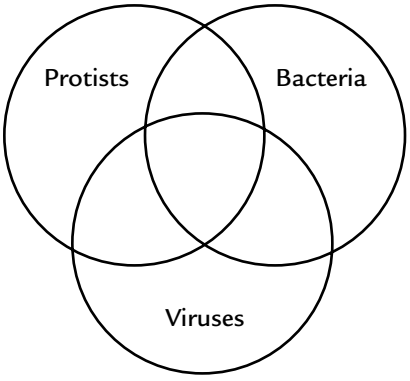
3. You have read how microbes can be both helpful and harmful to humans. Do you think a microbe can be *neither* helpful nor harmful? Explain.

4. You decide to examine some pond water under a microscope. With a magnification of 40 (using the 4x objective), you observe a long, cylindrical organism moving across your field of view (see left). As you look more closely, you notice what appears to be a round structure inside of it. Is this organism most likely a protist, bacterium, or virus? Explain how you arrived at your conclusion.

5. Suppose your school's microscopes did not have 40x objectives, but only 10x objectives. Your friend, who is in high school, uses a 40x objective. Explain what group of microbes he or she can study that you cannot.

6. What are the advantages of using the highest power objective on a microscope? What are the advantages of using the lowest power objective on a microscope? Explain.

7. In your science notebook, draw a larger version of the Venn diagram shown below. Record unique features of each group of microbes in the appropriate space. Record common features among groups in the spaces that overlap. **Hint:** Think about what you have learned about cells in the last few activities.



8. **Reflection:** On a field trip, you visit a laboratory that has an electron microscope. The microscopist (the person who runs the microscope) offers to set up a microbe for you to view. What microbe, or group of microbes, would you choose to view? Why?

EXTENSION

For links to more information about microbes, go the *Issues and Life Science* page of the SEPUP website.